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TITLE: ELECTROMAGNETIC INDUCTION HEATING DEVICE

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APPL-NO: JP63271453

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INT-CL (IPC): H05B006/10, F27D011/06

US-CL-CURRENT: 219/660, 219/669 , 219/672

ABSTRACT:

PURPOSE: To obtain an electromagnetic induction heating device of a high efficiency having less troubles of higher harmonics by connecting a secondary coil of a reactor inserted on the side of an AC power source serially with a second resonance capacitor and a second load coil for causing a serial resonance, and heating a subject matter auxiliarily by this resonance current.

CONSTITUTION: AC reactors 21-23, each having two coils, are engaged with three input lines 18-20 at a three-phase power source 12, and coils 25-27 for one side are formed at the three input lines 18-20, while three coils 28-30 for

the other side are serially connected with a second resonance capacitor 31, a regulating inductor 32 and a second load coil 33. The second resonance capacitor 31 makes a serial resonance with the second load coil 33, and a subject matter is auxiliarily heated by this resonance current. A higher harmonic current can thus be eliminated by a resonance circuit including the AC reactors each having two coils and the second load coil, and the higher harmonic current can be used effectively for auxiliary heating.

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⑫公開特許公報(A) 平2-117088

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⑬公開 平成2年(1990)5月1日

審査請求 未請求 請求項の数 1 (全3頁)

⑭発明の名称 電磁誘導加熱装置

⑳特願 昭63-271453
㉒出願 昭63(1988)10月26日

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明細書

1. 発明の名称

電磁誘導加熱装置

2. 特許請求の範囲

交流電源を整流して直流電流を得たあと、当該直流電流をインバータによって高周波電流に変換して負荷コイルで共振させるようにした電磁誘導加熱装置において、交流電源側に2次巻線を有するリアクトルを挿入し、該リアクトルの2次巻線と直列に第2の共振コンデンサー及び第2の負荷コイルを直列に接続して直列共振させ、この共振電流によって被加熱物を補助加熱するようにしたことを特徴とする電磁誘導加熱装置。

3. 発明の詳細な説明

(産業上の利用分野)

本発明は高周波によって例えば超硬用金属体などの被加工物を加熱するための電磁誘導加熱装置に関する。

(従来の技術)

従来、特開昭62-122089号公報には、三相交流電源(A)より入力された交流電流を第3図の如く三相全波整流器(B)で整流すると共に、該整流電流を平滑コンデンサー(C)で平滑にして直流電流に変換し、さらに多数のトランジスタ(D)(D)…を並列に接続したインバータ素子及びバランサーとしての共振コンデンサー(E)に接して高周波電流に変換したあと、負荷コイル(F)に印加して共振を生じせしめ、電磁誘導作用により負荷コイル(F)内の磁性体である被加工物を加熱することが記載されている。

(発明が解決しようとする課題)

しかし前記の電力変換装置においては、三相交流電源(A)より入力した交流電流より直流電流を得るために整流作用を行うとき、コンデンサー(C)に充電電流を流すため、三相交流電源(A)の各相の電流は通常、第4図の如く歪んだ波形になる。この波形は正弦波とは異なったものであり、基本正弦波(例えば50HZ、60HZ)に多くの高周波が重畳したものである。このように三相電源(A)の各相に高周波電流が流れると、電源系統のインピーダンスによる電圧降下、すなわち電

圧の高周波による被小物などの短絡障害を生ずる恐れがある。

本発明は上記の点に鑑み、電源側に高調波電流を流さないで、電力変換装置に発生する高調波電流を電気加熱のために有効に利用するようにしたものである。

（課題を解決するための手段）

本発明は上記目的を達成するために、交流電源を整流して直流電流を得たあと、当該直流電流をインバータによって高周波電流に変換して負荷コイルで共振させるようにした電磁誘導加熱装置において、交流電源側に2次巻線を有するリアクトルを挿入し、該リアクトルの2次巻線と直列に第2の共振コンデンサー及び第2の負荷コイルを直列に接続して直列共振させ、この共振電流によって被加工物を補助加熱するように構成したものである。

（作用）

本発明は三相交流電源が直流電流に変換されるために生ずる高周波電流成分は第2の負荷コイル(29)(30)を第2の共振コンデンサー(31)及び調整用インダクタ(32)並びに第2の負荷コイル(33)と直列に接続し、前記の第1負荷コイル(17)と第2負荷コイル(33)とを同軸で巻きつけている。なお前記の第2の共振コンデンサー(31)は第2の負荷コイル(33)と直列共振を行い、インダクタ(32)は前記の共振周波数を調整するものである。

しかして、前記の電磁誘導加熱装置を動作させたとき、すでに説明したような高周波電流が三相電源の入力線(18)(19)(20)に流れるが、当該高調波電流は通常、第3高調波、第5高調波、第7高調波のものが多く、ここでは第3高調波をなくす説明として共振コンデンサー(31)と第2負荷コイル(33)のインダクタンス及びインダクター(32)による共振周波数を第3高調波に選んだとすれば、その周波数に応じた電流は第2負荷コイル(33)の回路に流れ、電源系統に第3高調波は流れない。そして第2負荷コイル(33)へ流れた第3高調波電流は高調波の交番磁界を生じ、第2の負荷コイル(33)においても被加工物を補助加熱し、第1の負荷コイル(17)と共同して加熱作用を行う。

また交流リアクトルの他端の巻線(28)(29)(30)は通常のリアクトル作用を行うものであるため、全般の高調波電流を抑制する作用がある。

第2図の他の実施例において、電力変換器(41)の内部構造は第1図に示す電力変換器(11)と全く同じであり、三相電源(42)を介して前記電力変換器(41)に入力を行うと、変換された高周波電流が共振コンデンサー(43)を介して第1の負荷コイル(44)に送られる点は、第1図においてすでに説明した通りである。当該実施例が第1図と異なる点は、三相電源側に挿入した各リアクトル(45)(46)(47)の2次巻線(48)(49)(50)をそれぞれ独立させ、これら各リアクトルをそれぞれ別々の回路(51)(52)(53)を介して3個の第2の負荷コイル(54)(55)(56)に別々に接続すると共に、前記各回路にそれぞれ共振コンデンサー(57)(58)(59)及びインダクタ(60)(61)(62)を介設したものである。

第1図は、第3高調波が各相同相のためリアクトルの第2巻線を3台とも直列接続して、第3高

調波を除去する実施例であったが、第2図では任意な高調波次数について共振させるためにリアクトル(45)(46)(47)の2次巻線(48)(49)(50)を独立させて使用させようとするものである。動作原理、作用は第1図と同じであり、この電源回路を使用することにより、任意の高調波次数を除去できると共に、その電流を有効に活用して誘電加熱のためのエネルギーとすることができる。

(効果)

本発明によれば2巻線を有する交流リアクトルと第2の負荷コイルを含めた共振回路により電源側の高調波電流を除去すると共に、高調波電流を補助加熱のために有効に利用できるので、高調波障害が少なく自効率の良い電磁誘導加熱装置を提供できる効果ある。

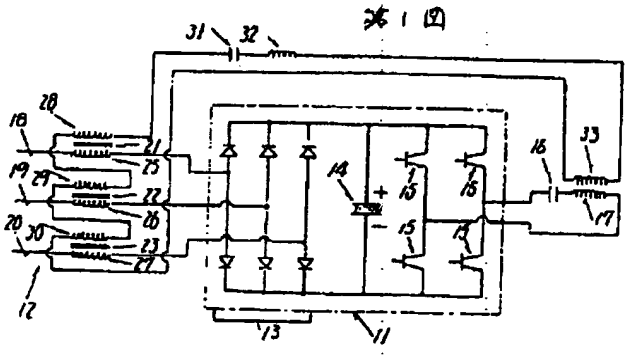
4. 図面の簡単な説明

第1図は本発明の実施例を示す電気回路図、第2図は他の実施例の説明図、第3図は従来の誘電加熱電源である電力変換装置の電気回路図、第4図は前図に記される波形の説明図である。

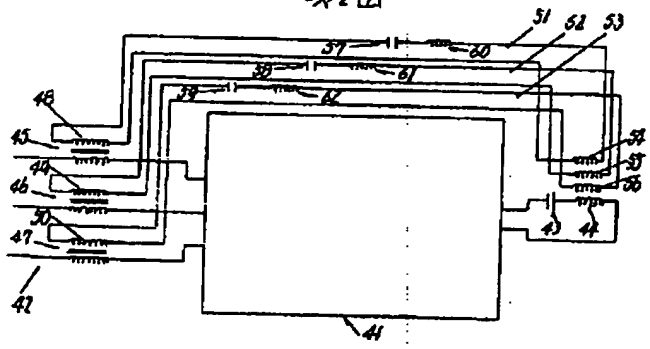
(11)…電力変換器、(12)…三相電源、(13)…整流器、(14)…平滑コンデンサー、(15)…トランジスタ、(16)…共振コンデンサ、(17)…第1の負荷コイル、(18.19.20)…入力線、(21.22.23)…交流リアクトル、(25.26.27.28.29.30)…導線、(31)…第2の共振コンデンサ、(33)…第2の負荷コイル、(45.46.47)…交流リアクトル、(48.49.50)…導線、(54.55.56)…第2の負荷コイル、(57.58.59)…第2の共振コンデンサ、(60.61.62)…調整用インダクタ。

出願人 立 綱 康 彦 外1名

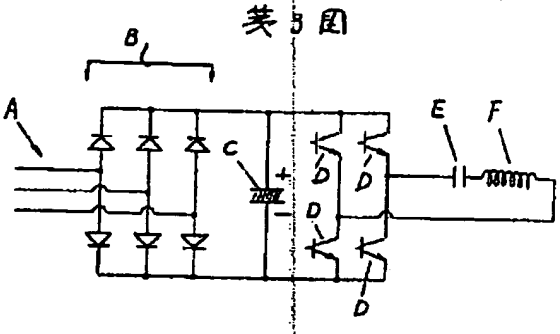
第1図



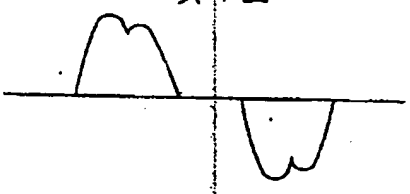
第2図



第3図



第4図



PTO 05-3134

Japanese Kokai Patent Application
No. Hei 2[1990]-117088

ELECTROMAGNETIC INDUCTION HEATING DEVICE

Tsuneo Watanabe and Yasuhiko Kitazumi

UNITED STATES PATENT AND TRADEMARK OFFICE
WASHINGTON, D.C. APRIL 2005
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7139-4K

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Publication Date: May 1, 1990

No. of Claims: 1 (Total of 3 pages)

Examination Request: Not filed

ELECTROMAGNETIC INDUCTION HEATING DEVICE

[Denji yudo kanetsu sochi]

Inventors: Tsuneo Watanabe and
Yasuhiko Kitazumi

Applicant: Uchino Machinery Works Ltd.

[There are no amendments to this patent.]

Claim

A type of electromagnetic induction heating device characterized by the following facts: in the electromagnetic induction heating device, AC power is rectified to obtain a DC current, and the DC current is converted to an RF current by means of an inverter to make a load coil resonate; in this electromagnetic induction heating device, a reactor having a secondary winding is inserted in the AC power source side; a second resonant capacitor and a second load coil are connected in series to the secondary winding of said reactor to perform series resonance; and, by means of the resonant current, the workpiece for heating is heated in an auxiliary way.

Detailed explanation of the invention

Industrial application field

The present invention pertains to a type of electromagnetic induction heating device for heating a metal rod for forging or another workpiece with RF.

Prior art

In the prior art described in Japanese Kokai Patent Application No. Sho 62[1987]-122089, as shown in Figure 3, the AC current input to 3-phase power source (A) is rectified with 3-phase full-wave rectifier (B), and then the rectified current is smoothened with smoothing capacitor (C) to have a DC current. Then, the current is converted to an RF current as it flows in an inverter element with plural transistors (D), (D)... connected in parallel and in resonant capacitor (C) as a balancer. Then, the obtained RF current is applied on load coil (F) to generate resonance, and, by means of the electromagnetic induction function, the workpiece as a magnetic member in load coil (F) is heated.

Problems to be solved by the invention

However, in said power conversion device, when rectifying is performed to obtain a DC current from the AC current input to 3-phase power source (A), a charging current flows in capacitor (C). Consequently, the line currents of the various lines of 3-phase AC power source (A) usually become the distorted waveforms shown in Figure 4. Such waveforms differ from the sinusoidal wave, and they have plural harmonics superimposed on a fundamental sinusoidal wave (such as 50 Hz, 60 Hz). As RF current flows in the lines of said 3-phase AC power source (A), due to the impedance of the power source system, voltage fall; that is, minute variation in the voltage due to the harmonics may cause trouble for the power source.

The purpose of the present invention is to solve the aforementioned problems of the prior art by providing a method in which no harmonic current flows on the power source side, and the harmonic current generated in the power conversion device can be used effectively in electric heating.

Means to solve the problems

In order to realize the aforementioned purpose, the present invention provides a type of electromagnetic induction heating device characterized by the following facts: in the electromagnetic induction heating device, AC power is rectified to obtain a DC current, and the DC current is converted to an RF current by means of an inverter to make a load coil resonate; in this electromagnetic induction heating device, a reactor having a secondary winding is inserted in the AC power source side; a second resonant capacitor and a second load coil are connected in

series to the secondary winding of said reactor to perform series resonance; and, by means of the resonant current, the workpiece for heating is heated in an auxiliary way.

Operation

According to the present invention, because the RF current component generated due to conversion from the 3-phase AC power source to the DC current flows in the resonant circuit of the second load coil, no RF current flows on the power source side, and, due to the electromagnetic induction function of the ampere-turn magnetomotive force of the current flowing in the second load coil, the workpiece in the coil is heated.

Application examples

Power converter (11) shown in Figure 1 has rectifier (13) and smoothing capacitor (14) for rectifying the AC current input from 3-phase AC power source (12) to a DC current, and it also has plural transistors (15), (15).... as inverter elements for converting the DC current to an RF current. Also, resonant capacitor (16) and first load coil (17) are connected, and the workpiece is heated with said first load coil (17).

On the other hand, AC reactors (21), (22), (23) each having two windings are coupled to three input lines (18), (19), (20) in said 3-phase AC power source (12); one-side windings (25), (26), (27) are formed on said three input lines (18), (19), (20); and, at the same time, three windings (28), (29), (30) on the other side are connected in series to second resonant capacitor (31), adjusting inductor (32), and second load coil (33), with said first load coil (17) and second load coil (33) coaxially wound. Also, said second resonant capacitor (31) performs series resonance with second load coil (33), and inductor (32) is for adjusting said resonance frequency.

However, when said electromagnetic induction heating device works, as explained in the above, harmonic current flows in input lines (18), (19), (20) of the 3-phase AC power source. Said harmonic current usually contains strong 3rd, 5th, and 7th harmonics. Here, explanation will be made on the case of elimination of the 3rd harmonic. By selecting the resonance frequency of resonant capacitor (31) and the inductance of 2nd load coil (33) as well as inductor (32) at the 3rd harmonic, a current corresponding to said frequency flows in the circuit of 2nd load coil (33), and the 3rd harmonic does not flow in the power source system. The 3rd harmonic current flowing in 2nd load coil (33) generates an AC magnetic field, and the workpiece is heated in an auxiliary way in 2nd load coil (33), and, together with 1st load coil (17), the heating operation is performed.

Also, windings (28), (29), (30) on the other side of the AC reactor perform the conventional reactor function; they work to suppress the overall harmonic current.

Figure 2 is a diagram illustrating another application example. The internal structure of power converter (41) is entirely the same as power converter (11) shown in Figure 1. As power is

input through 3-phase AC power source (42) into said power converter (41), the converted RF current is sent via resonant capacitor (43) to first load coil (44). This is the same as that explained with reference to Figure 1. This application example differs from that shown in Figure 1 in that secondary coils (48), (49), (50) of reactors (45), (46), (47) insulated on the 3-phase AC power source side are independent from each other, and the reactors are connected via individual circuits (51), (52), (53) to three second load coils (54), (55), (56), respectively. At the same time, resonant capacitors (57), (58), (59) and inductors (60), (61), (62) are set in said circuits, respectively.

Figure 1 illustrates Application Example 1 in which three second windings of the reactors are connected in series to remove the 3rd harmonic because the 3rd harmonic is in phase for the various phase. On the other hand, in the scheme shown in Figure 2, secondary windings (48), (49), (50) of reactors (45), (46), (47) are used independently so as to make resonance for any harmonic order. The operation principle and function are the same as those of Figure 1. By using this electric circuit, it is possible to remove any harmonic order, and, at the same time, the current can be used effectively as the energy in dielectric heating.

Effects

According to the present invention, the harmonic current on the power source side is removed by means of a resonant circuit containing an AC reactor having two windings and a second load coil, and, at the same time, the harmonic current can be used effectively for auxiliary heating. Consequently, it provides a type of electromagnetic induction heating device with no harmonic problem and with a high efficiency.

Brief description of the figures

Figure 1 is a diagram illustrating the electric circuit in an application example of the present invention. Figure 2 is a diagram illustrating another application example. Figure 3 is a diagram illustrating the electric circuit of a power converter as the dielectric heating power source in the prior art. Figure 4 is a diagram illustrating the phenomenon that takes place in said figure.

11	Power converter
12	3-phase AC power source
13	Rectifier
14	Smoothing capacitor
15	Transistor
16	Resonant capacitor

17	First load coil
18, 19, 20	Input line
21, 22, 23	AC reactor
25, 26, 27, 28, 29, 30	Winding
31	Second resonant capacitor
33	Second load coil
45, 46, 47	AC reactor
48, 49, 50	Winding
54, 55, 56	Second load coil
57, 58, 59	Second resonant capacitor
60, 61, 62	Inductor for adjustment

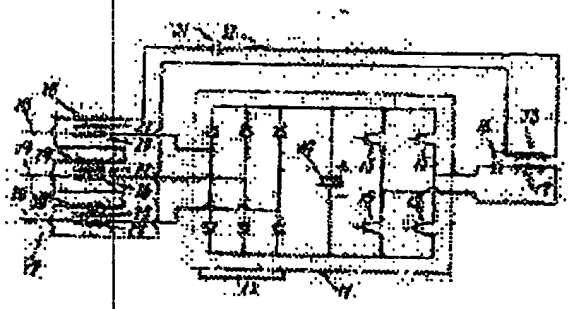

Figure 1

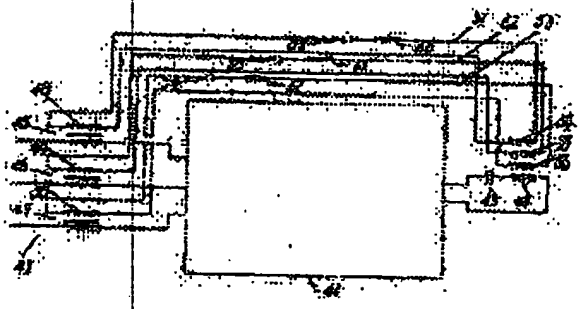

Figure 2

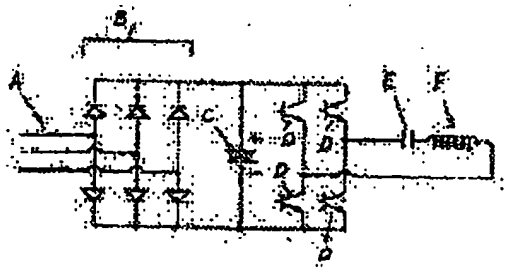

Figure 3

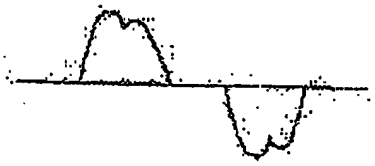

Figure 4

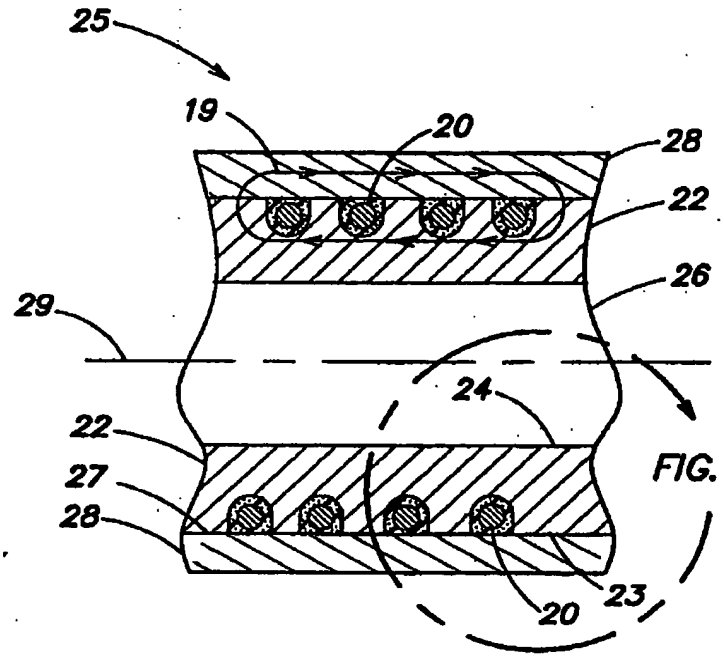

FIG. 1B

FIG. 1A

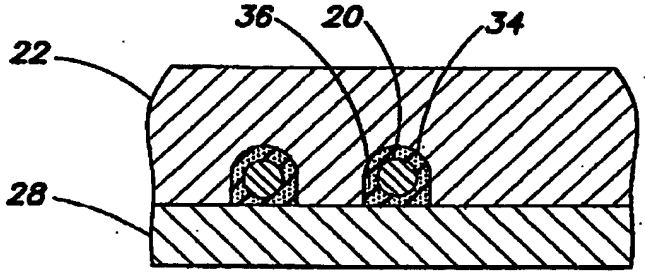

FIG. 1B

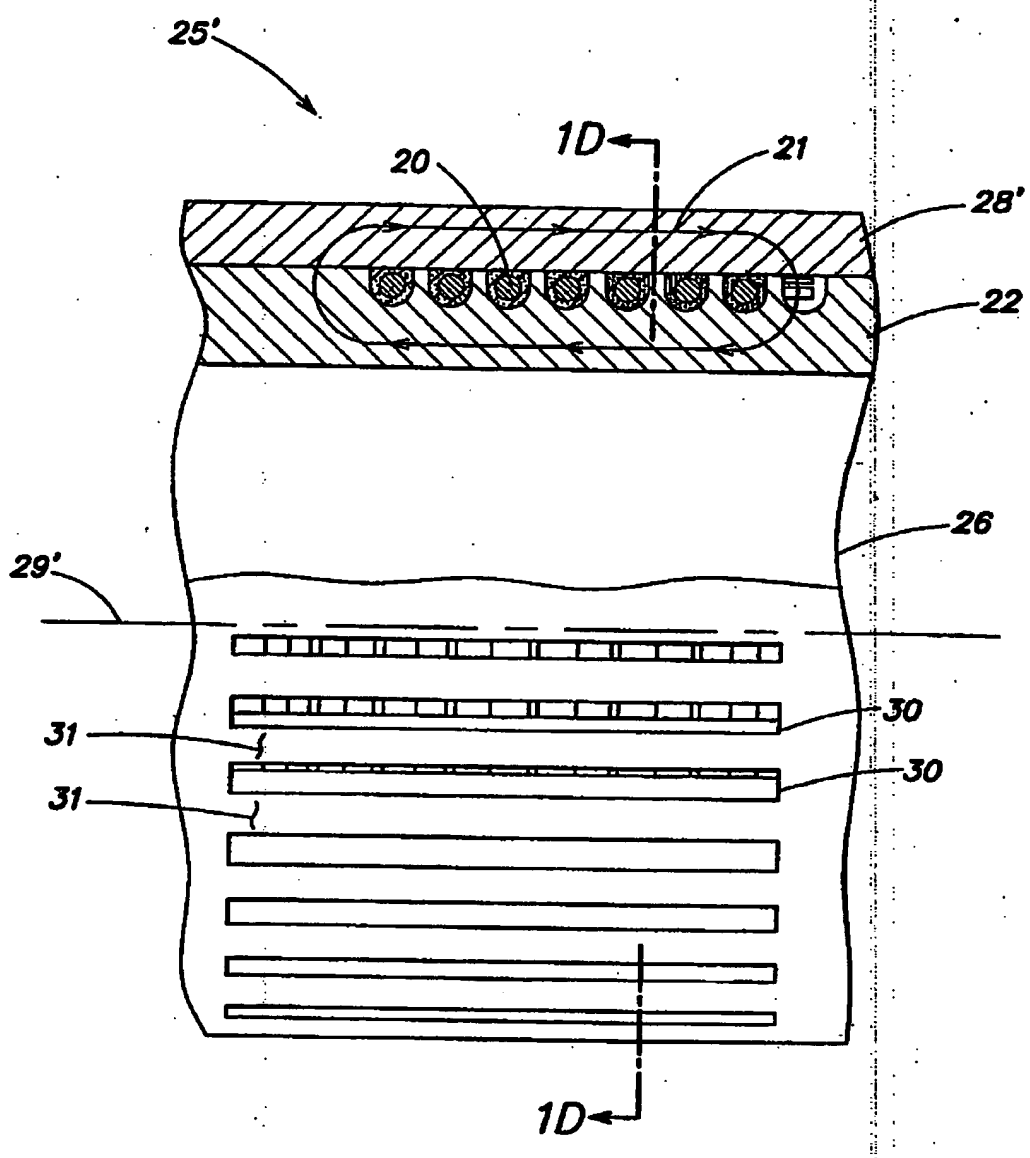

FIG. 1C

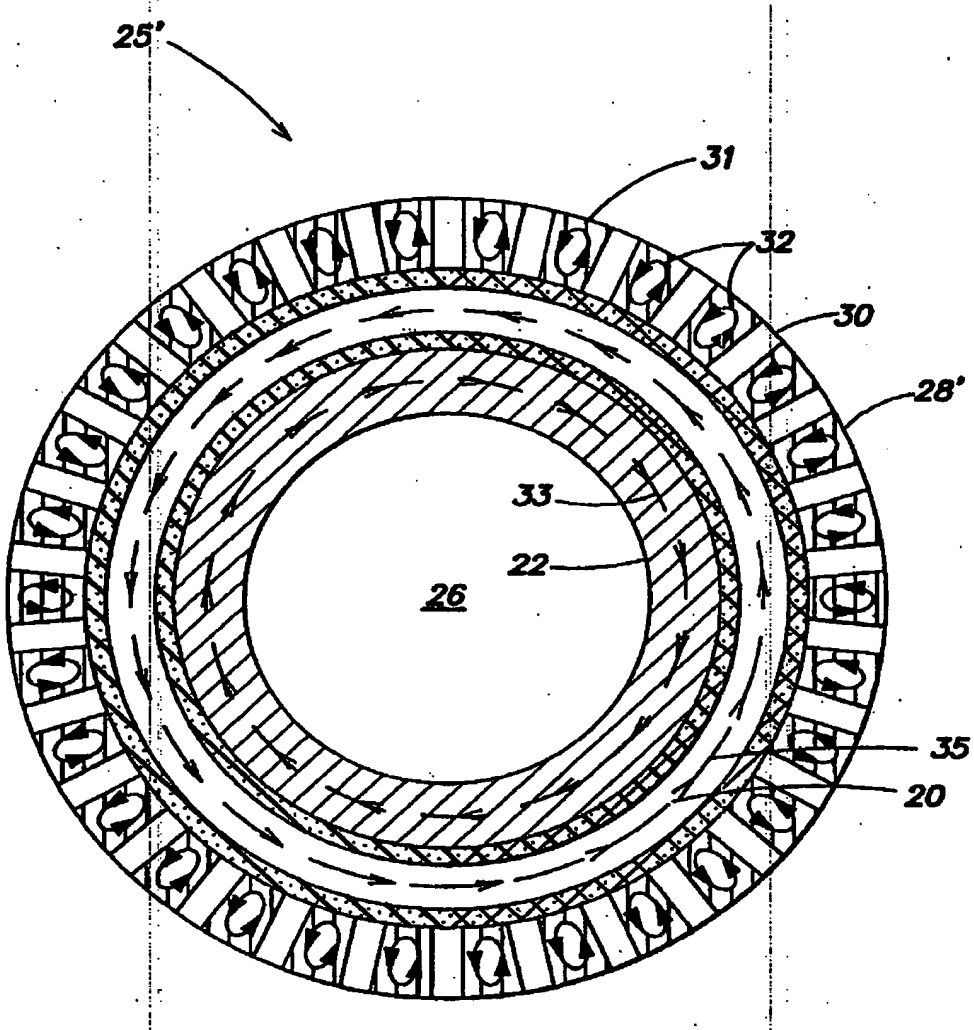

FIG. 1D

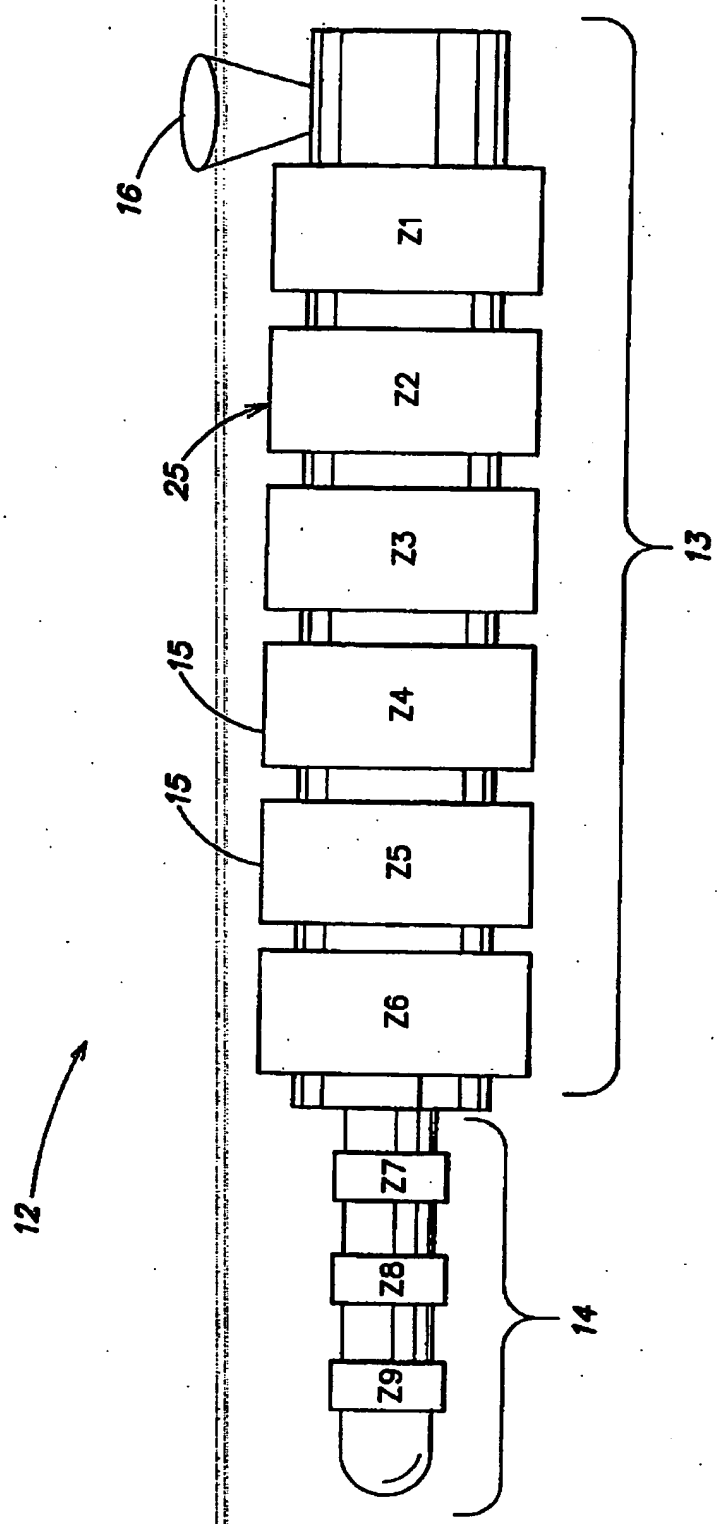

FIG. 1E

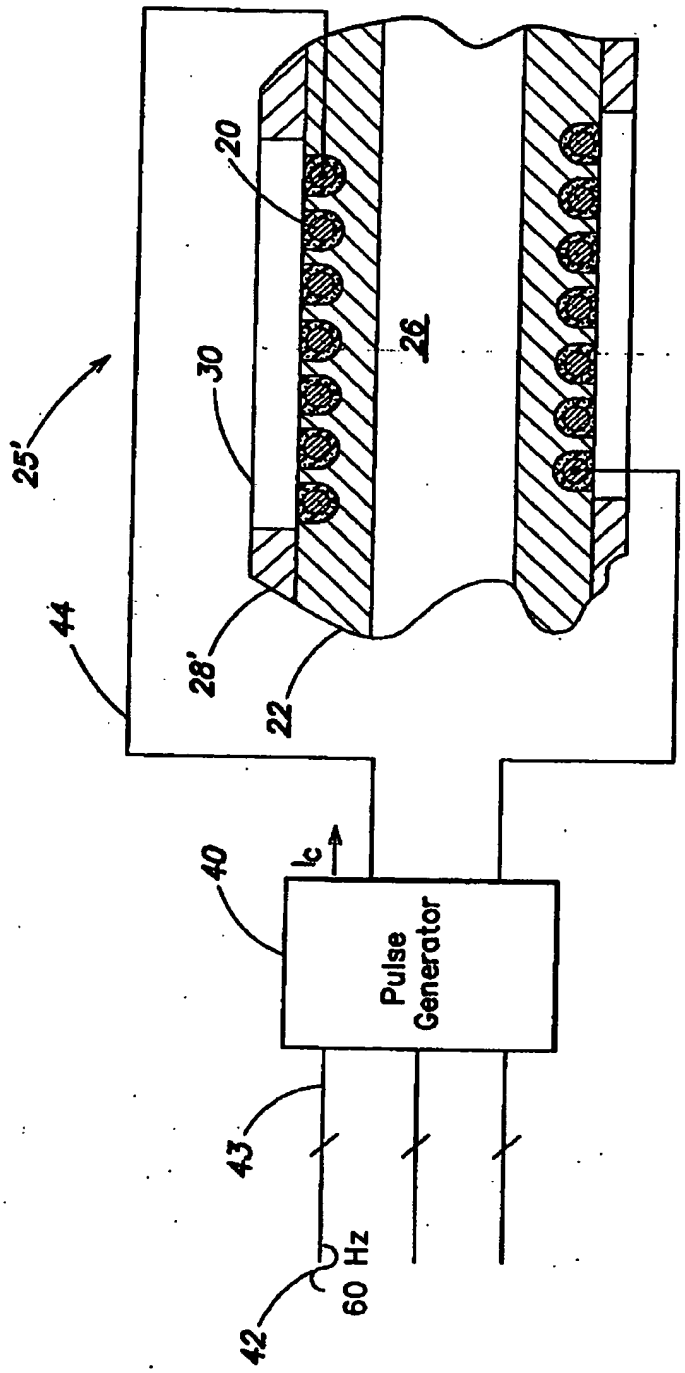

FIG. 2

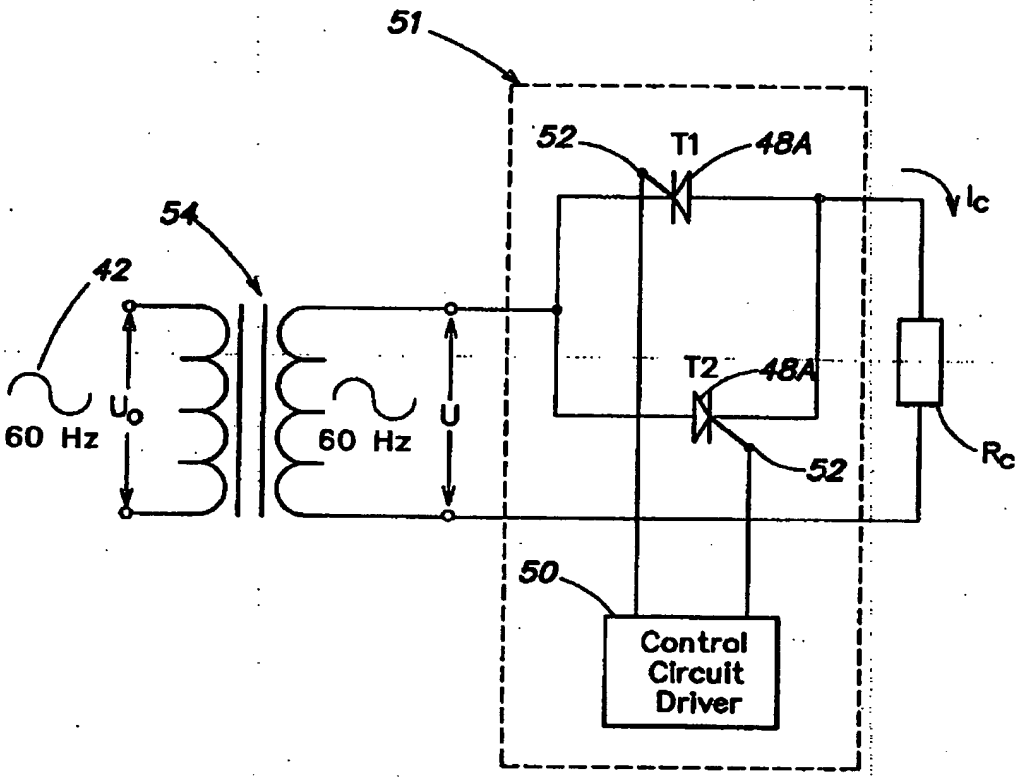
51
52
T1
48A
Ic
54
42
60 Hz
U_o
60 Hz
U
T2
48A
52
R_c
50
Control Circuit Driver

FIG. 3A

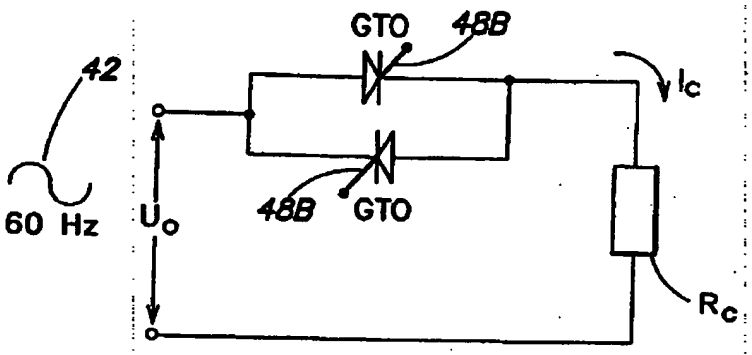
GTO
48B
42
Ic
60 Hz
Uo
48B
GTO
Rc

FIG. 3B

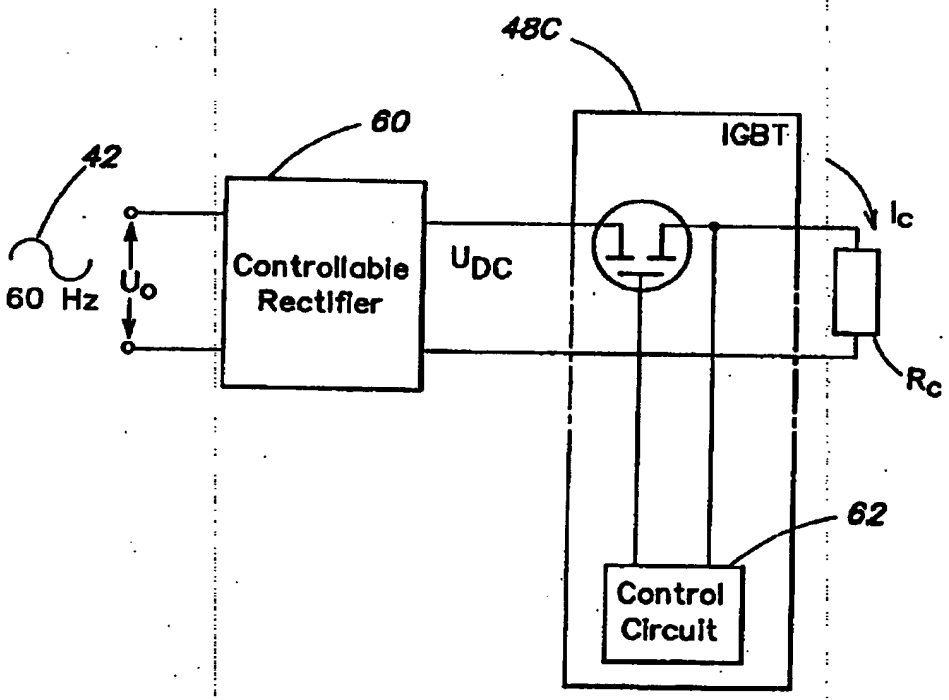
48C
60
IGBT
42
Ic
Uo
60 Hz
Controllable Rectifier
UDC
Rc
62
Control Circuit

FIG. 3C

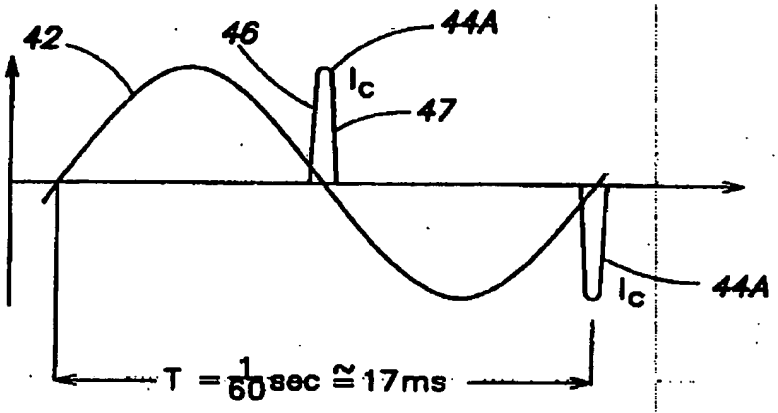

FIG. 4A

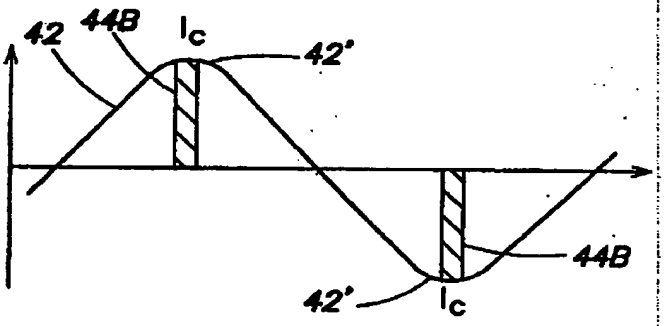

FIG. 4B

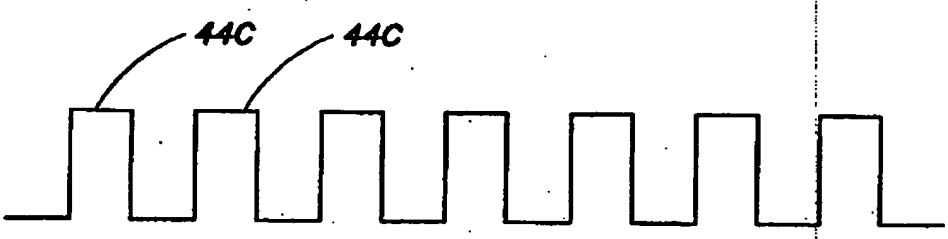

FIG. 4C

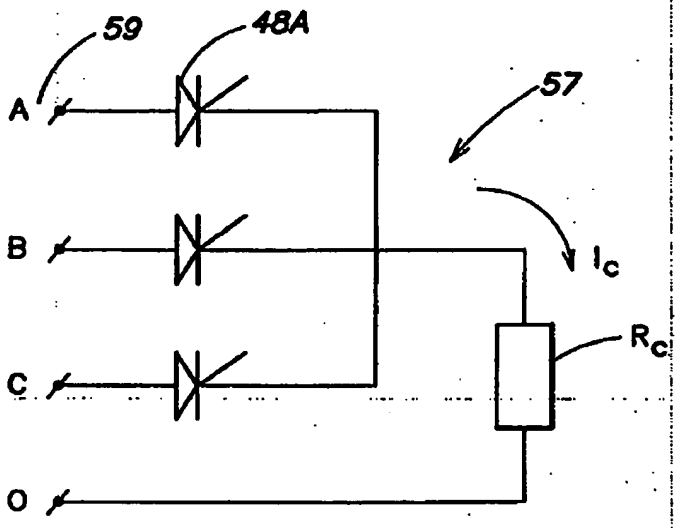
59
48A
57
A
B
C
O
I_C
R_C

FIG. 5A

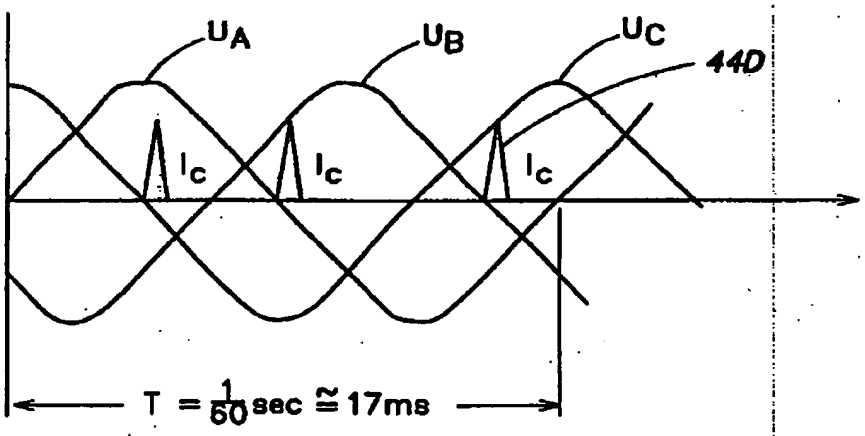
U_A
U_B
U_C
44D
I_C
I_C
I_C
$T = \frac{1}{60}\text{sec} \cong 17\text{ms}$

FIG. 6A

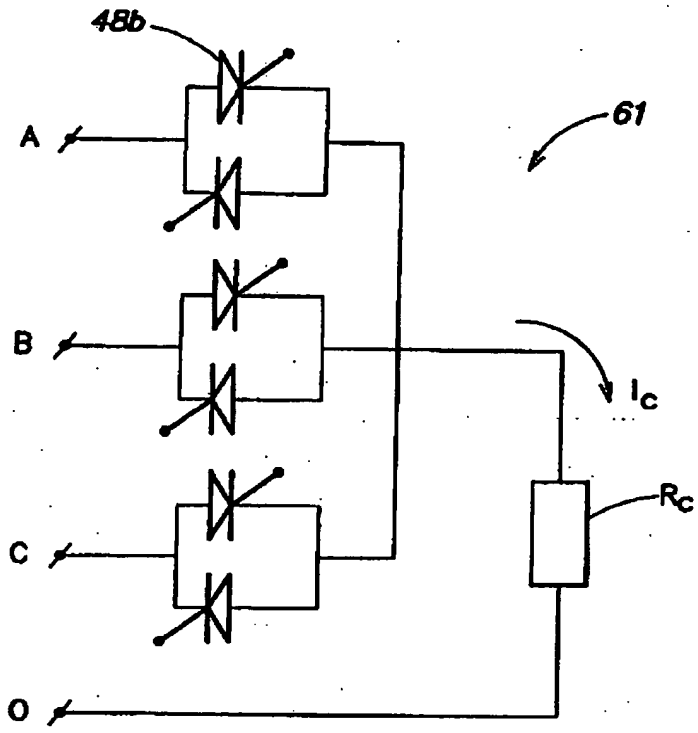

FIG. 5B

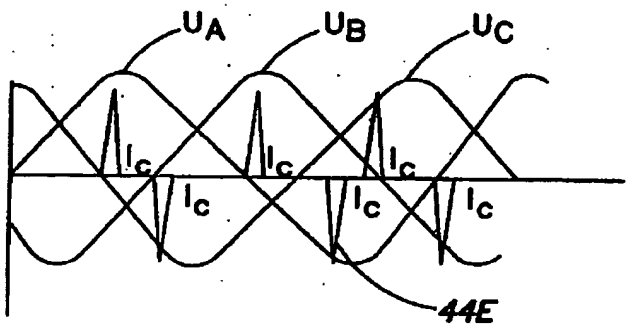

FIG. 6B

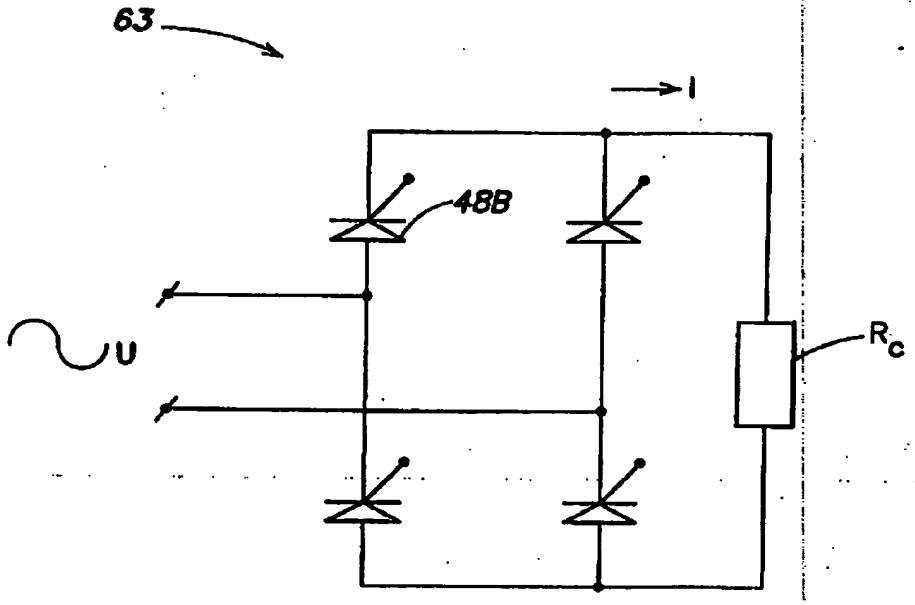

FIG. 5C

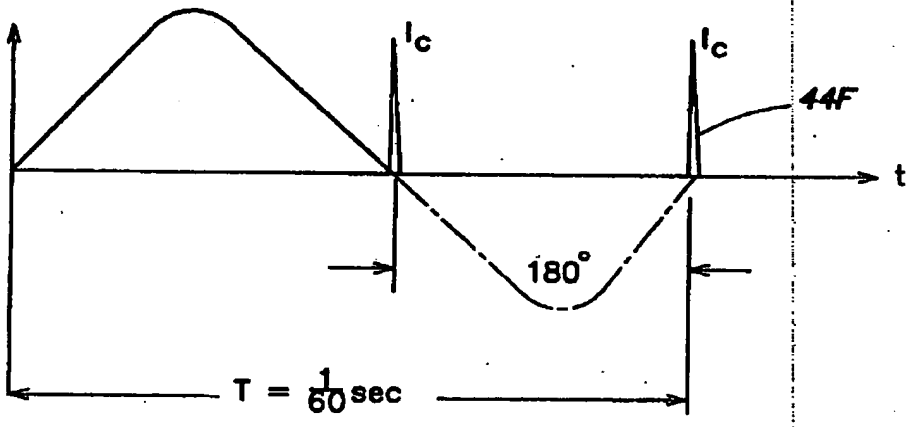

FIG. 6C

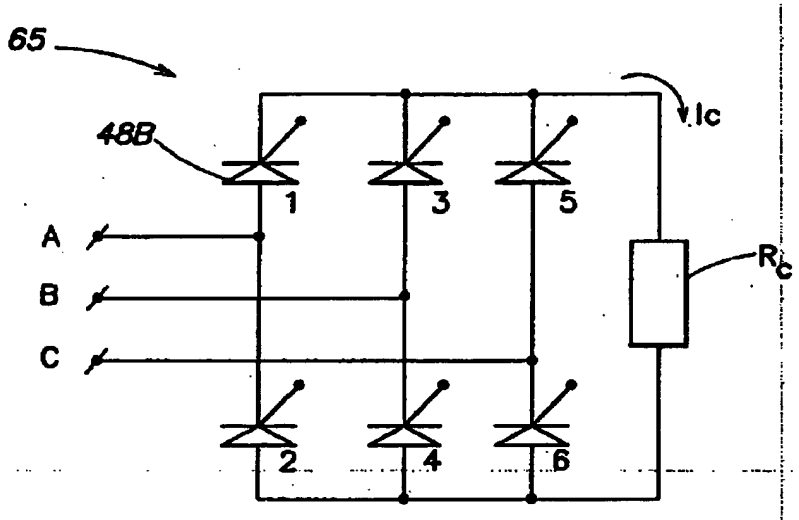
65
48B
Ic
1
3
5
A
B
C
R_c
2
4
6

FIG. 5D

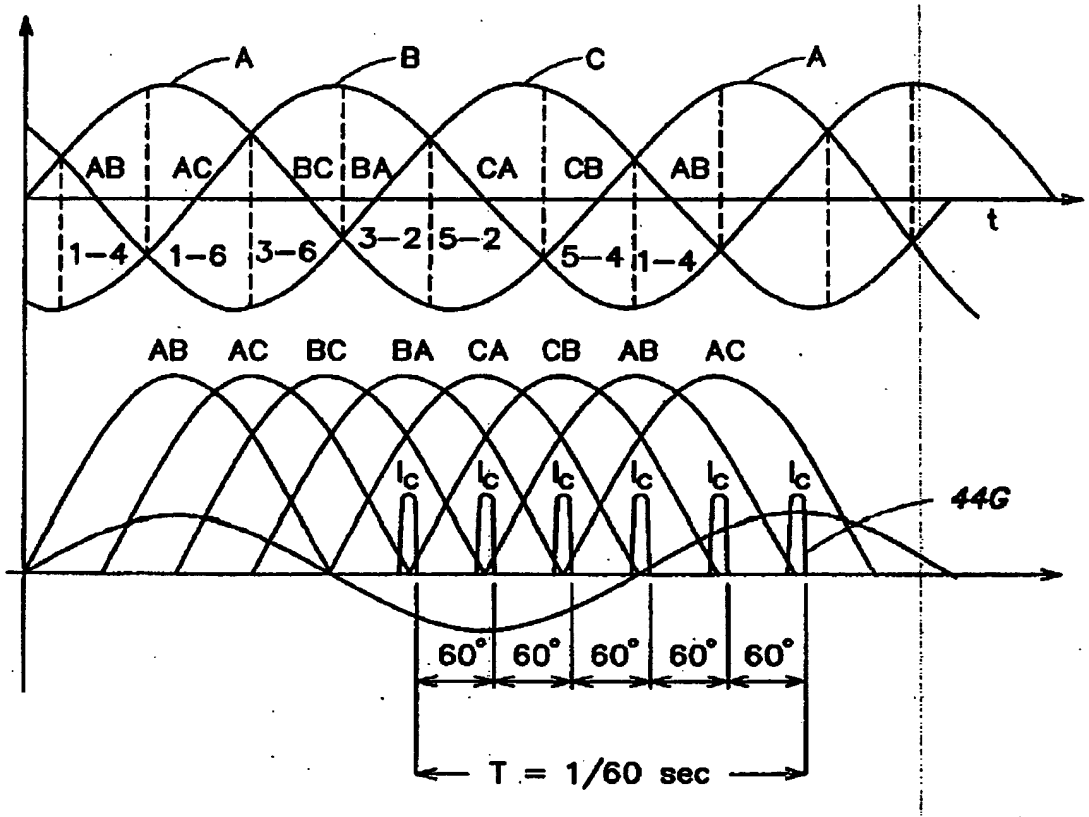
A
B
C
A
AB
AC
BC
BA
CA
CB
AB
t
1–4
1–6
3–6
3–2
5–2
5–4
1–4
AB
AC
BC
BA
CA
CB
AB
AC
I_c
44G
60°
60°
60°
60°
60°
T = 1/60 sec

FIG. 6D

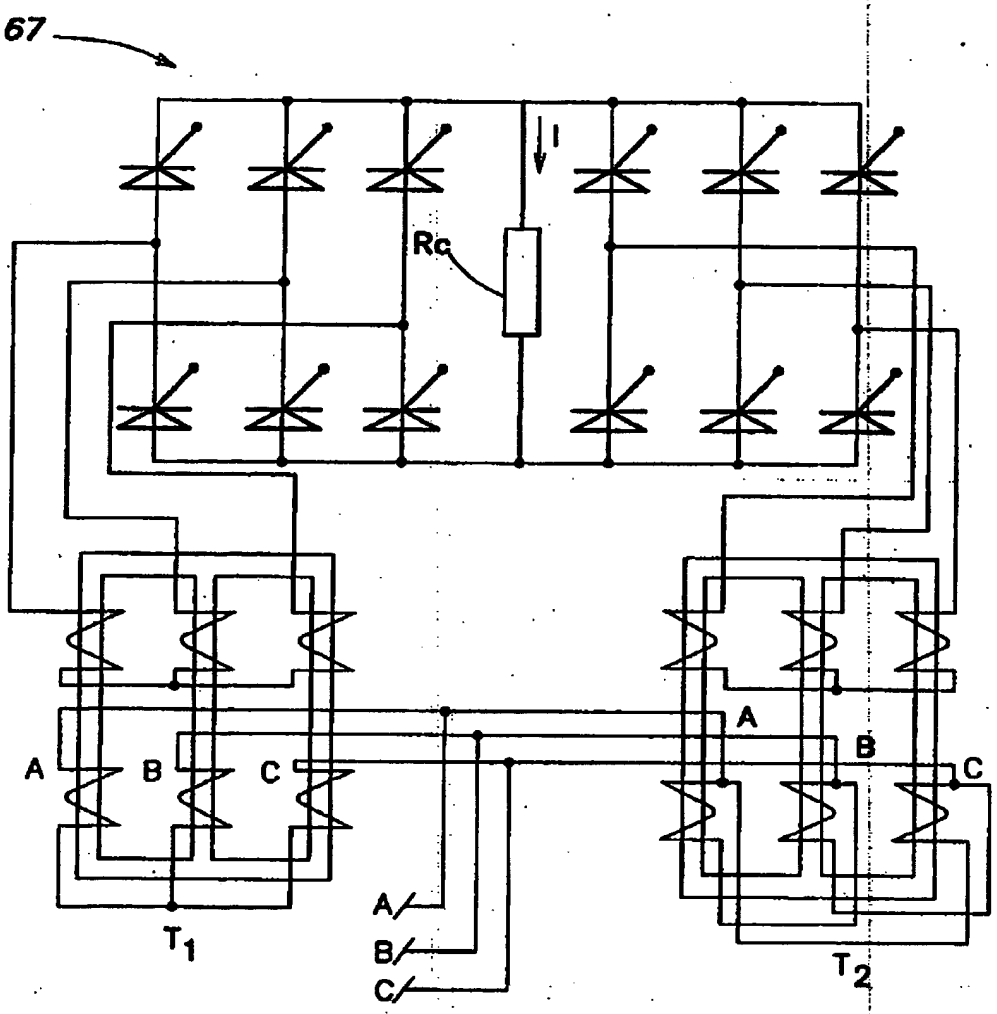
67
I
Rc
A
B
C
A
B
C
A
B
C
T1
T2

FIG. 5E

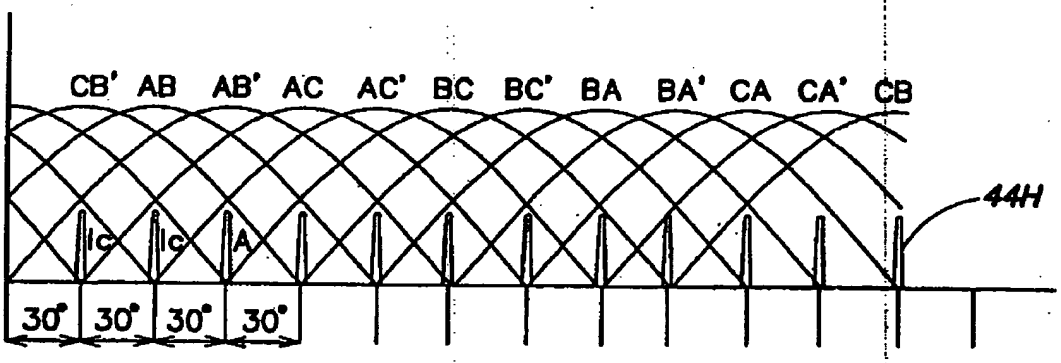
CB' AB AB' AC AC' BC BC' BA BA' CA CA' CB
44H
Ic
Ic
A
30°
30°
30°
30°

FIG. 6E

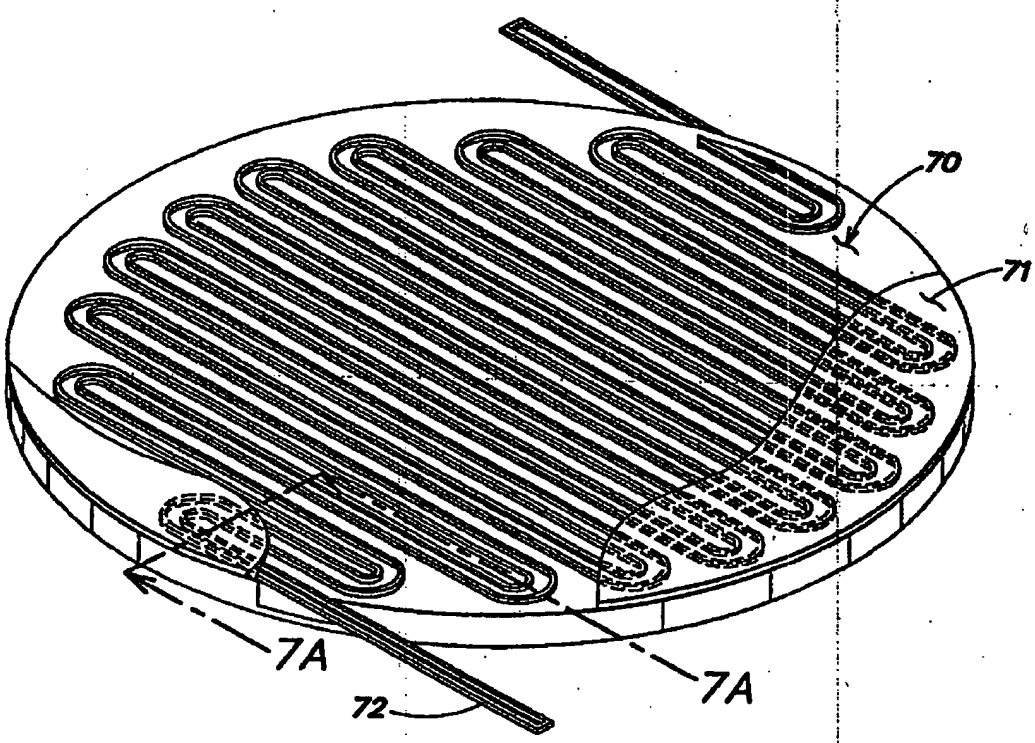

FIG. 7

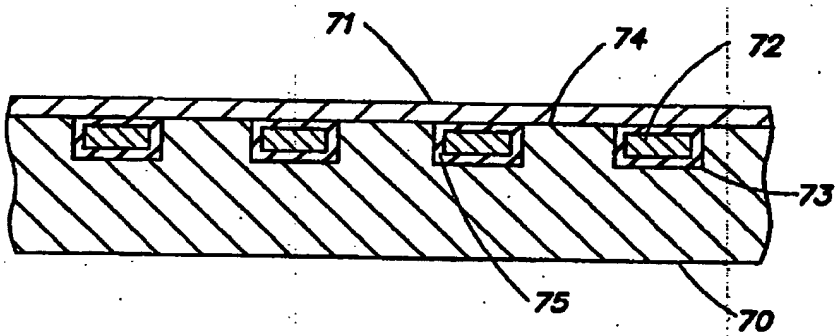

FIG. 7A

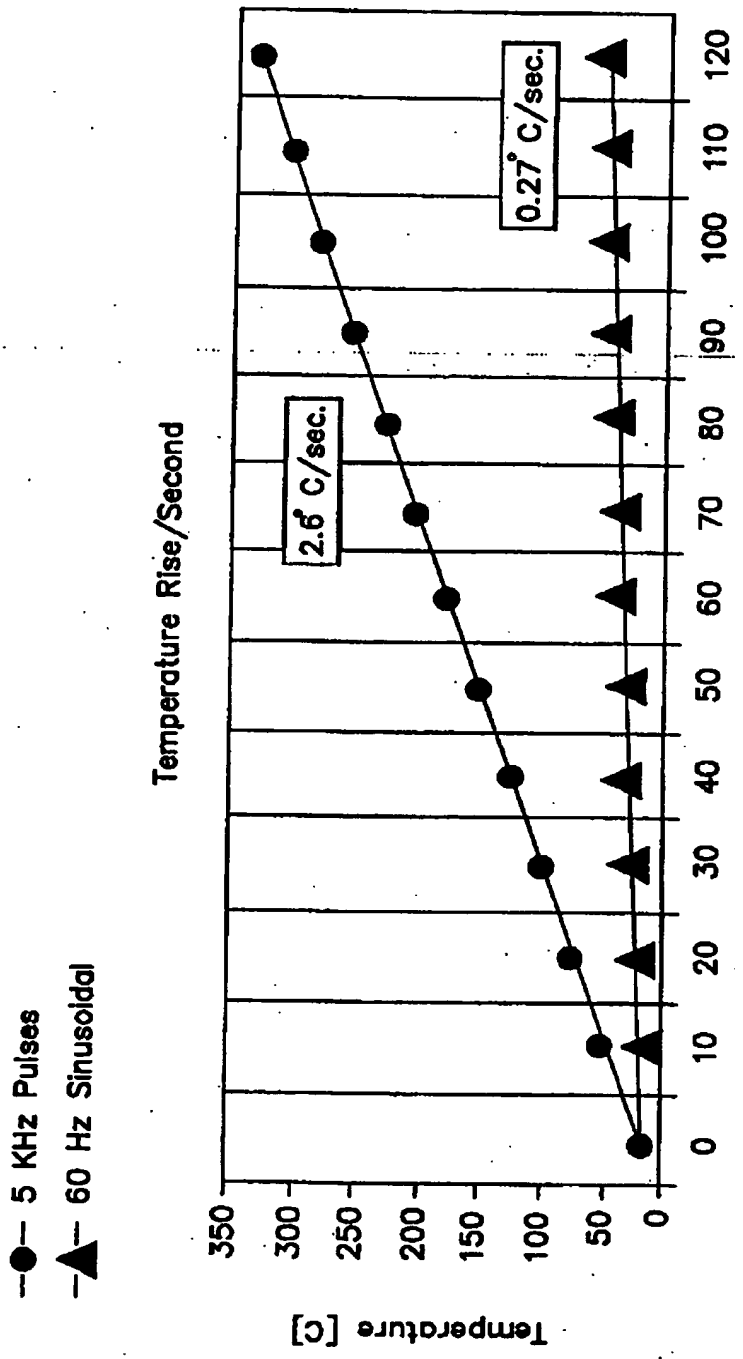
Temperature Rise/Second
Temperature [C]
350
300
250
200
150
100
50
0
0
10
20
30
40
50
60
70
80
90
100
110
120
Time [Seconds]
2.6° C/sec.
0.27° C/sec.
5 KHz Pulses
60 Hz Sinusoidal

FIG. 8

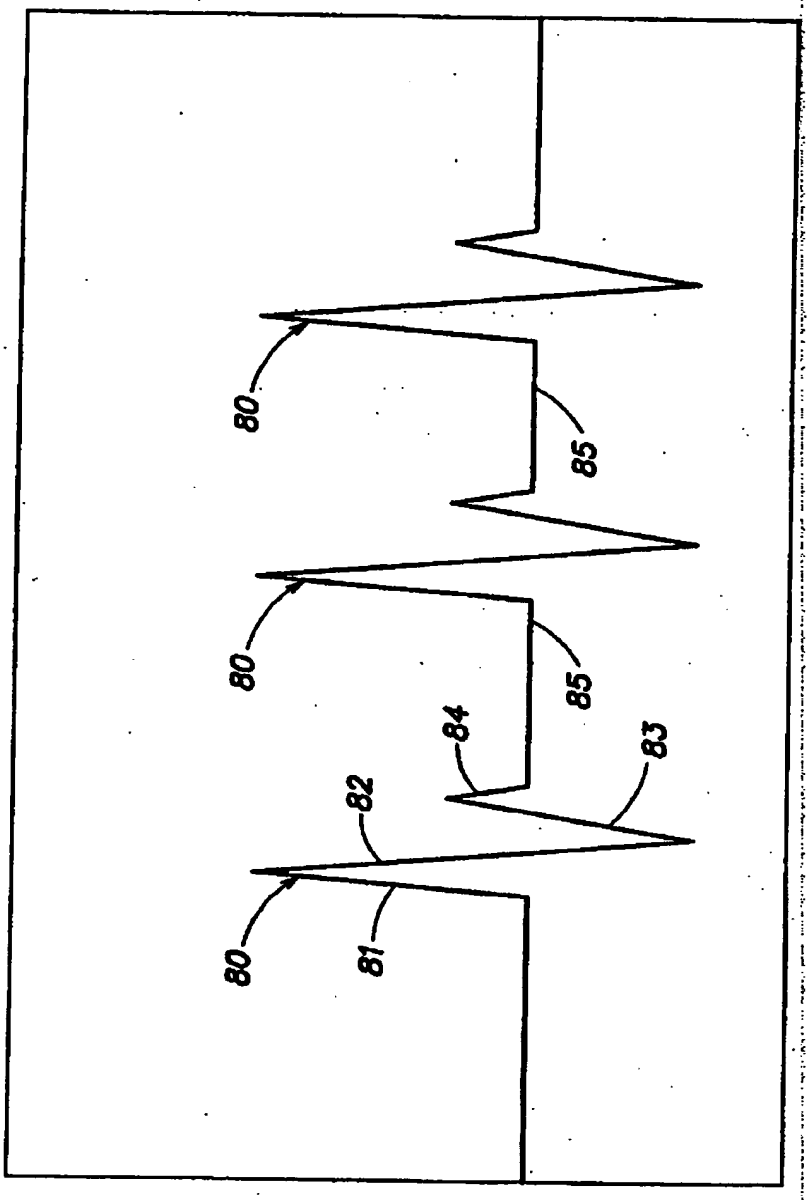

FIG. 9

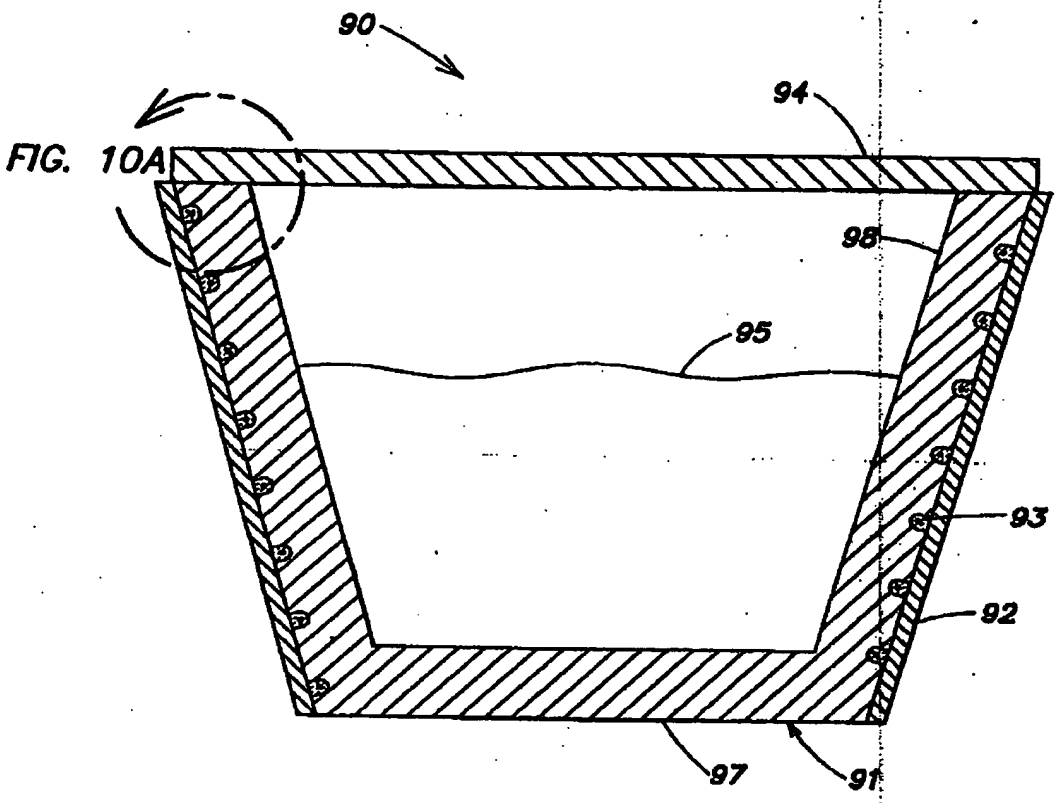

FIG. 10A

FIG. 10

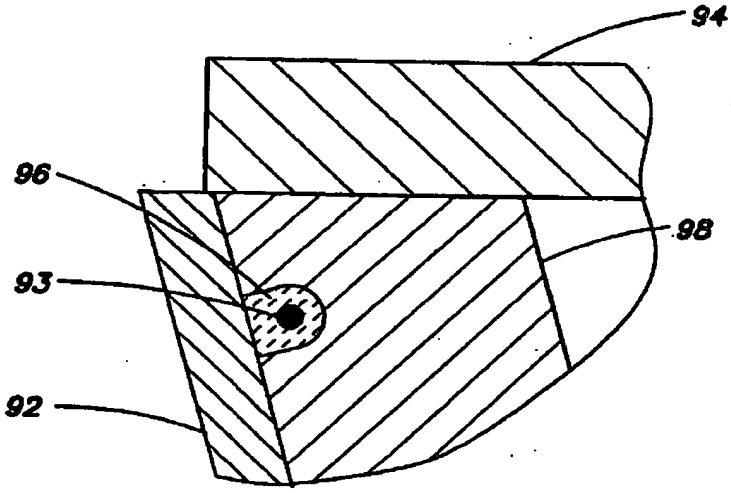

FIG. 10A

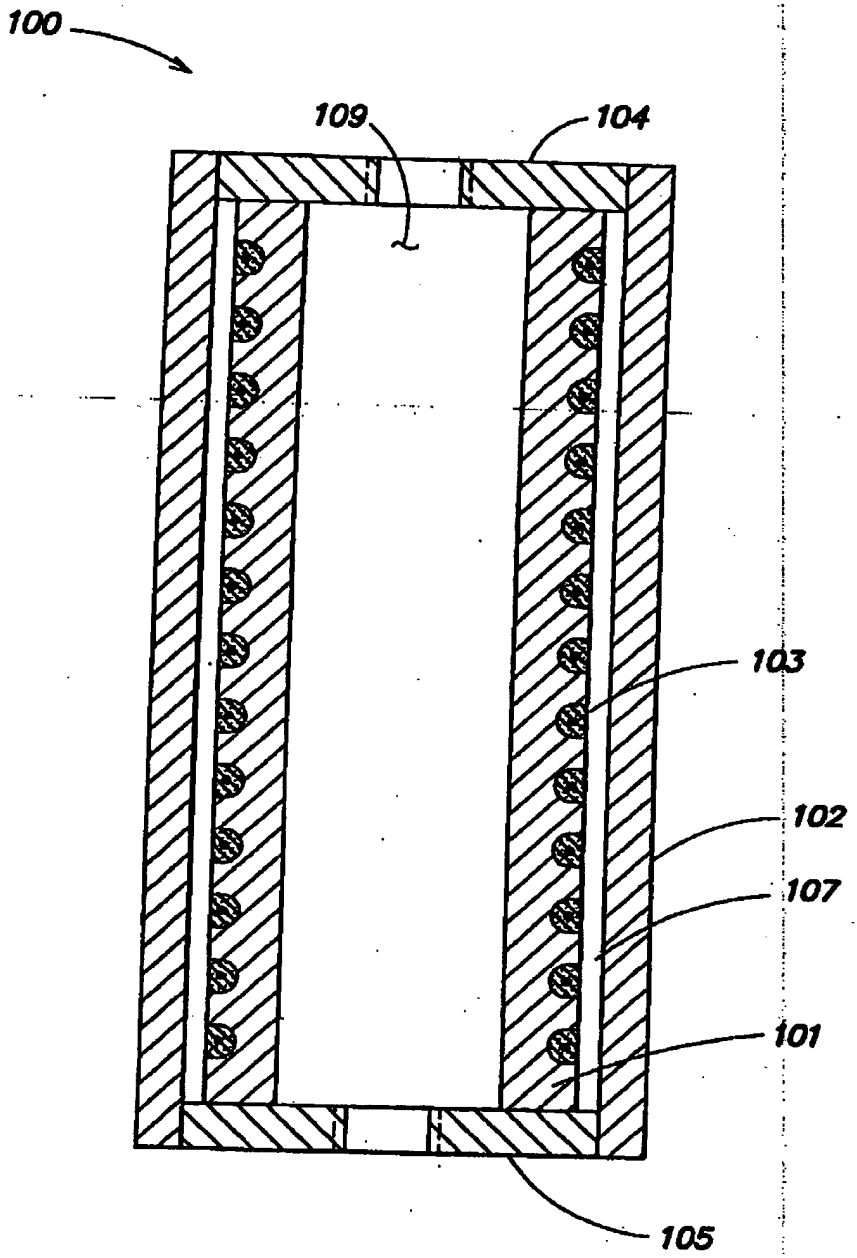

FIG. 11

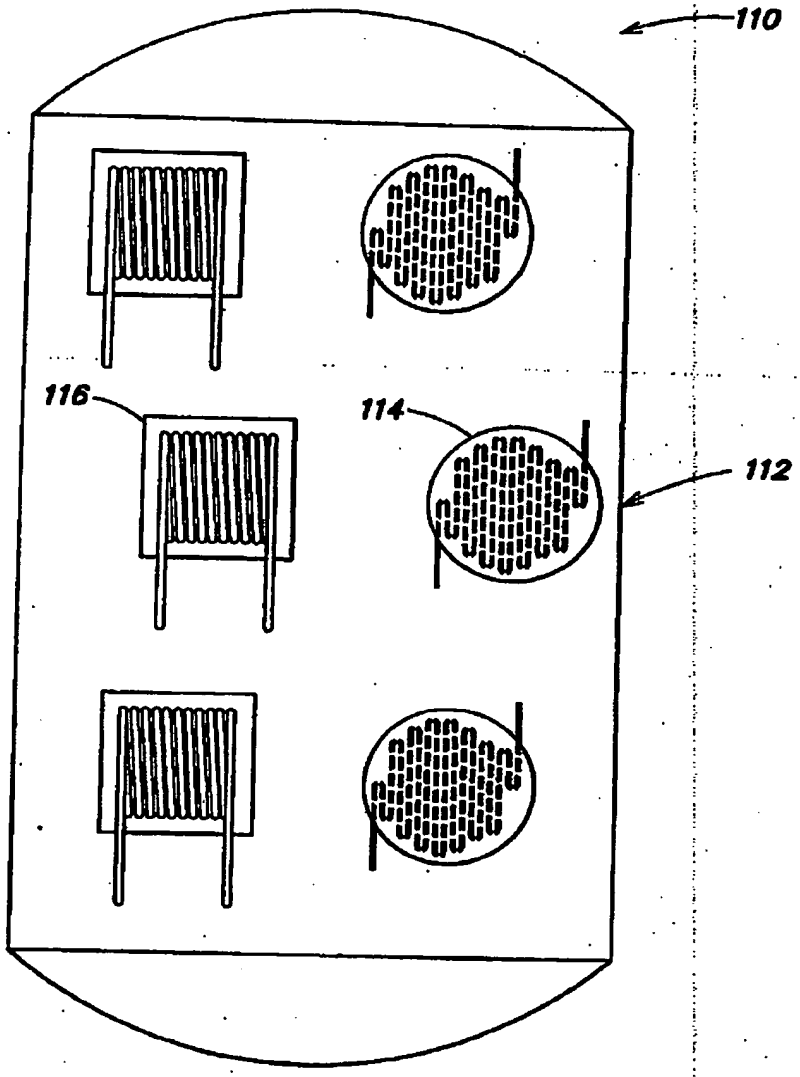

FIG. 12